



AMENDMENT UNDER 37 C.F.R. § 1.114(c)
U.S. Appl. No.: 10/029,204

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

Claim 1. (currently amended): A magnetic recording medium comprising, in sequence, on a nonmagnetic substrate:

at least one soft magnetic underlayer;

an orientation control layer ~~to control the orientation of the layer immediately thereabove;~~

and

a nonmagnetic intermediate layer; and

a perpendicular magnetic layer having an axis of easy magnetization which is oriented mainly perpendicularly to the nonmagnetic substrate,

wherein said orientation control layer is provided to control the orientation of the perpendicular magnetic layer,

said nonmagnetic intermediate layer is provided between the orientation control layer and the perpendicular magnetic layer to improve the orientability and the coercive force of the perpendicular magnetic layer.

said soft magnetic underlayer has a multilayer structure consisting of a plurality of soft magnetic layers comprising a soft magnetic material, and one or more separation layers interposed between said soft magnetic layers,

~~at least one of said soft magnetic layers comprises a material with a structure having no magnetic domain walls,~~

a direction of magnetization of an upper soft magnetic layer is different from a direction of magnetization of a lower soft magnetic layer, and

the direction of the magnetization of said soft magnetic layer is along the radius of said nonmagnetic substrate and is oriented towards the periphery of the substrate or towards the center of said nonmagnetic substrate.

Claim 2. (previously presented): A magnetic recording medium according to claim 1, wherein the material with a structure having no magnetic domain walls ~~is~~ comprises one selected from FeAlSi, FeTaN, FeTaC, FeC, FeAlSi alloys, FeTaN alloys, and FeTaC alloys.

Claim 3. (previously presented): A magnetic recording medium according to claim 1, wherein the separation layer comprises 50 at. % or more of one or more of the elements Ru, Rh, Re, Ir, and Cu.

Claim 4. (previously presented): A magnetic recording medium according to claim 1, wherein the separation layer is constituted of a soft magnetic material that is different from the material constituting the soft magnetic layers between which the separation layer is interposed.

Claim 5. (previously presented): A magnetic recording medium according to claim 1, wherein the product $B_s \cdot t$ (T · nm) of the saturation magnetic flux density per layer B_s (T) of the soft magnetic layer and the thickness of the soft magnetic layer t (nm), is 3 T · nm or more for each of the soft magnetic layers.

Claim 6. (previously presented): A magnetic recording medium according to claim 1, wherein the magnetic flux density of the soft magnetic layer is 0.4 T or more.

Claim 7. (previously presented): A magnetic recording medium according to claim 1, wherein the thickness of the soft magnetic underlayer is 40 nm or more.

Claim 8. (original): A magnetic recording medium according to claim 1, wherein the thickness of the separation layer is in the range from 0.1 nm to 5 nm.

Claim 9. (canceled).

Claim 10. (previously presented): A magnetic recording medium according to claim 1, wherein among sets of an upper and a lower soft magnetic layers between which a separation layer is interposed, at least one set has directions of magnetization which are antiparallel.

Claim 11. (canceled).

Claim 12. (previously presented): A magnetic recording medium according to claim 1, wherein a hard magnetic layer is formed between the nonmagnetic substrate and the soft magnetic underlayer, and the magnetization of said hard magnetic layer is directed along the radius of the substrate and towards the periphery or the center of the substrate, and bonded with

the magnetization of the soft magnetic layer which is the lowest layer of the soft magnetic underlayer.

Claim 13. (previously presented): A magnetic recording medium according to claim 1, wherein the lowest layer of the soft magnetic underlayer comprises a material of one selected from the group consisting of FeAlSi, FeTaN, FeTaC, FeAlSi alloys, FeTaN alloys, and FeTaC alloys.

Claim 14. (previously presented): A magnetic recording medium according to claim 1, wherein the top layer of the soft magnetic underlayer is a soft magnetic layer.

Claim 15. (previously presented): A magnetic recording medium according to claim 1, wherein a part of the surface or all of the surface of the soft magnetic underlayer nearest the perpendicular magnetic layer is oxidized.

Claim 16. (currently amended): A method for producing a magnetic recording medium on a nonmagnetic substrate, comprising the steps of:

forming at least one soft magnetic underlayer,

forming an orientation control layer ~~for controlling the orientation of the layer~~
~~immediately above, and~~

forming a nonmagnetic intermediate layer; and

forming a perpendicular magnetic layer having an axis of easy magnetization which is oriented mainly perpendicularly to the substrate,

wherein said orientation control layer is provided to control the orientation of the perpendicular magnetic layer,

said nonmagnetic intermediate layer is provided to improve the orientability and the coercive force of the perpendicular magnetic layer,

the soft magnetic underlayer having a multilayer structure consisting of a plurality of soft magnetic layers comprising a soft magnetic material, and one or more separation layers interposed between said soft magnetic layers,

~~one or more of the soft magnetic layers comprises a material with a structure having no magnetic domain walls, and~~

a magnetization of said soft magnetic layer is directed along the radius of said nonmagnetic substrate towards the periphery or the center of said nonmagnetic substrate.

Claim 17. (previously presented): A method for producing a magnetic recording medium according to claim 16, wherein the material with a structure having no magnetic domain walls comprises one selected from the group consisting of FeAlSi, FeTaN, FeTaC, FeC, FeAlSi alloys, FeTaN alloys, and FeTaC alloys.

Claim 18. (canceled).

Claim 19. (previously presented): A method for producing a magnetic recording medium according to claim 16 wherein a treatment for oxidizing the surface of the soft magnetic underlayer is included.

Claim 20. (currently amended): A magnetic recording and reproducing device comprising:

a magnetic recording medium having ~~at least~~ a nonmagnetic substrate, a at least one soft magnetic underlayer, an orientation control layer ~~to control the orientation of the layer immediately above it,~~ a nonmagnetic intermediate layer and a perpendicular magnetic layer having an axis of easy magnetization which is oriented mainly perpendicularly to the nonmagnetic substrate; and

~~and~~ a magnetic head for carrying out recording and reproducing of the information to and from the magnetic recording medium,

wherein said orientation control layer is provided to control the orientation of the perpendicular magnetic layer,

said nonmagnetic intermediate layer is provided between the orientation control layer and the perpendicular magnetic layer to improve the orientability and the coercive force of the perpendicular magnetic layer,

the soft magnetic underlayer of the magnetic recording medium has a multilayer structure consisting of a plurality of soft magnetic layers comprising a soft magnetic material, and one or more separation layers interposed between the soft magnetic layers,

~~one or more of the soft magnetic layers comprises a material with a structure having no magnetic domain walls, and~~

a magnetization of said soft magnetic layer is directed along the radius of said nonmagnetic substrate towards the periphery or the center of said nonmagnetic structure.

Claim 21. (previously presented): A magnetic recording and reproducing device according to claim 20, wherein the material with a structure having no magnetic domain walls comprises one selected from the group consisting of FeAlSi, FeTaN, FeTaC, FeC, FeAlSi alloys, FeTaN alloys, and FeTaC alloys.

Claim 22. (previously presented) A magnetic recording medium according to claim 1, wherein the thickness of the orientation control layer is in the range from 8 nm to 50 nm.

Claim 23. (previously presented) A magnetic recording medium according to claim 1, wherein the material of the orientation control layer comprises one selected from NiAl, FeAl, CoFe, CoZr, AlCo, Zr, Y, Zn, Ru, Re, Hf, Ni, Pd, Pt, Al, Cu, Ag, Ir, Si, Co, and Si or Co alloys.

Claim 24. (previously presented) A method for producing a magnetic recording medium according to claim 16, wherein the thickness of the orientation control layer is in the range from 8 nm to 50 nm.

Claim 25. (previously presented): A method for producing a magnetic recording medium according to claim 16, wherein the material of the orientation control layer comprises one selected from NiAl, FeAl, CoFe, CoZr, AlCo, Zr, Y, Zn, Ru, Re, Hf, Ni, Pd, Pt, Al, Cu, Ag, Ir, Si, Co, and Si or Co alloys.

Claim 26. (New) A magnetic recording medium according to claim 1, further comprising:

a magnetization stabilizing layer comprising a soft magnetic material formed on the perpendicular magnetic layer; and

a protective layer on the magnetization stabilizing layer.

Claim 27. (New) A magnetic recording medium comprising, in sequence, on a nonmagnetic substrate:

at least one soft magnetic underlayer;

an orientation control layer;

a perpendicular magnetic layer having an axis of easy magnetization which is oriented mainly perpendicularly to the nonmagnetic substrate, wherein said orientation control layer is provided to control the orientation of the perpendicular magnetic layer;

a magnetization stabilizing layer comprising a soft magnetic material formed on the perpendicular magnetic layer; and

a protective layer on the magnetization stabilizing layer,

wherein said soft magnetic underlayer has a multilayer structure consisting of a plurality of soft magnetic layers comprising a soft magnetic material, and one or more separation layers interposed between said soft magnetic layers, at least one of said soft magnetic layers,

a direction of magnetization of an upper soft magnetic layer is different from a direction of magnetization of a lower soft magnetic layer, and

the direction of the magnetization of said soft magnetic layer is along the radius of said nonmagnetic substrate and is oriented towards the periphery of the substrate or towards the center of said nonmagnetic substrate.

Claim 28. (New) A method for producing a magnetic recording medium on a nonmagnetic substrate, comprising the steps of:

forming at least one soft magnetic underlayer;

forming an orientation control layer;

forming a perpendicular magnetic layer having an axis of easy magnetization which is oriented mainly perpendicularly to the nonmagnetic substrate, wherein said orientation control layer is provided to control the orientation of the perpendicular magnetic layer;

forming a magnetization stabilizing layer comprising a soft magnetic material formed on the perpendicular magnetic layer; and

forming a protective layer on the magnetization stabilizing layer,

wherein said soft magnetic underlayer has a multilayer structure consisting of a plurality of soft magnetic layers comprising a soft magnetic material, and one or more separation layers interposed between said soft magnetic layers, at least one of said soft magnetic layers,

a direction of magnetization of an upper soft magnetic layer is different from a direction of magnetization of a lower soft magnetic layer, and

the direction of the magnetization of said soft magnetic layer is along the radius of said nonmagnetic substrate and is oriented towards the periphery of the substrate or towards the center of said nonmagnetic substrate.

Claim 29. (New) A magnetic recording and reproducing device comprising:

a magnetic recording medium having a nonmagnetic substrate, at least one soft magnetic underlayer, an orientation control layer, a perpendicular magnetic layer having an axis of easy magnetization which is oriented mainly perpendicularly to the nonmagnetic substrate, wherein said orientation control layer is provided to control the orientation of the perpendicular magnetic layer, a magnetization stabilizing layer comprising a soft magnetic material formed on the perpendicular magnetic layer, and a protective layer on the magnetization stabilizing layer; and

a magnetic head for carrying out recording and reproducing of information to and from the magnetic recording medium,

wherein said soft magnetic underlayer has a multilayer structure consisting of a plurality of soft magnetic layers comprising a soft magnetic material, and one or more separation layers interposed between said soft magnetic layers, at least one of said soft magnetic layers,

a direction of magnetization of an upper soft magnetic layer is different from a direction of magnetization of a lower soft magnetic layer, and

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the direction of the magnetization of said soft magnetic layer is along the radius of said nonmagnetic substrate and is oriented towards the periphery of the substrate or towards the center of said nonmagnetic substrate.